Using Multiple Amendments and Delivery Methods to Treat Extensive PCE Impacts in Low-Permeability Soil and Bedrock Matrices

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Background/Objectives. Releases of perchloroethene (PCE) during former dry-cleaning activities resulted in significant impacts within a complex, subsurface setting. Affected matrices include low-permeability residuum overlying incised and fractured claystone and sandstone bedrock. Solute concentrations indicative of dense-non-aqueous-phase-liquid (DNAPL) extend to depths 40 feet below an unconfined water table. Situated on a hill (limb of an anticline), paleo-channels (incised, erosional features) and a relatively steep groundwater gradient have caused a dissolved-phase plume to extend more than 1/4-mile downhill from the source. Since the plume is largely overlain by a residential community, initial concerns included determining the extent to which fugitive emissions are causing indoor-air-quality (IAQ) risks to homeowners. To add to the complexity of the project, there is also an upgradient source of PCE groundwater impact from across the street.

The site qualified for a state voluntary clean-up program. The on-coming, groundwater mass discharge from the adjacent property and IAQ findings (20 residences sampled) were used to determine a risk-based, clean-up target for groundwater. Impacted soil was mitigated via excavation, to the extent practicable outside the building (not inside).

Approach/Activities. The aboveground PCE tank was removed from the site in the late 1990s, when the dry cleaners closed. PCE-impacted soil was later excavated, followed by pilot testing in situ groundwater treatment using BOS 100®, an immiscible, activated carbon solid injectate. An extensive hydrology study was conducted to evaluate if plume expansion could be caused by gradient increases from temporary hydraulic mounding during injection.

The onsite, dissolved-phase groundwater plume was treated using BOS 100® technology. Performance monitoring was conducted and further high-resolution assessment data were obtained to develop a more accurate conceptual site model of the source area and to evaluate the cause-and-effect and remedy alternatives for downgradient, offsite impacts.

Mass flux/mass discharge calculations were used along selected transects to evaluate plume strength at the property boundary. The final remedy included installing a sodium permanganate direct-delivery system in the source area. Angled borings (up to 45°) were drilled as part of the infiltration gallery to gain access to deep impacts and deliver remedy reagent beneath the building. Offsite threats were addressed by constructing subsurface, permeable reactive barriers (PRBs) using BOS 100® at the property boundary and along a parallel street downgradient of the site, a block away. Innovative packer assemblies were used to isolate targeted zones for jet injection in deep bedrock. Intrinsic shearing of the BOS solids improved remedy distribution.

Results/Lessons Learned. The project has been successful because of the effectiveness of the trident approach, i.e., soil excavation in the source and adjacent areas, continual delivery of sodium permanganate to treat source area groundwater and DNAPL, and the stalwart presence of BOS 100® within the dissolved-phase plume and in PRBs at strategic locations at the property boundary and offsite. To date (4 months after the final remedy was installed), PCE impacts have been reduced from concentrations up to 62,000 micrograms per kilogram in soil and 184,000 micrograms per liter in groundwater, to near risk-based target levels. A No Action Determination for the site will be obtained, once voluntary clean-up objectives have been met.